Using Structured Decision Making to Manage and Monitor Reconstructed Prairies – A Review

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28 March 2013

ABSTRACT/SUMMARY

Early in 2012, US Fish and Wildlife Service Region 3 staff began discussions because there was a need to learn more about reconstructed prairie habitats and their associated grassland birds through monitoring efforts. Through these discussions it was decided that a face-to-face structured decision making workshop was necessary to properly work through the issue. The workshop was help at Neal Smith National Wildlife Refuge on November 26-30, 2012 with 21 participants. During this workshop, the complexity of decisions managers face while reconstructing prairies was brought to light. The participants defined fundamental and means objectives, created an objectives hierarchy, and came up with lists of alternative actions for prairie reconstructions and management. Major uncertainties/questions were identified and a list of products the participants desired to help better reconstruct prairies was compiled. The next steps for moving this project forward were also identified.

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INTRODUCTION

This report summarizes the information derived from a workshop focused on the topic of reconstructing prairies. Discussions held in preparation for the workshop indicated that the establishment phase of prairie reconstructions, especially reconstructions conducted on land previously in row crop production, were of most interest to land managers in FWS Regions 3 and 6. The workshop was held at Neal Smith National Wildlife Refuge on November 26-30, 2012.

This group defines a reconstructed prairie as one that has no bears no resemblance to a natural, native community before reconstruction efforts. Reconstructed prairies are not remnant, native prairies. Reconstructed prairies usually have a cropping history and either start as black dirt or a degraded, planted grassland that was cropped at some time in the past.

NEEDS ASSESSMENT

During the summer of 2011, the US Fish and Wildlife Service (USFWS), Region 3 (R3) Division of Biological Resources (DBR) committed to surveying all Refuges, Wetland Management Districts, and Private Lands Offices in the Midwest Region to understand the greatest science needs, management concerns, and limitations to meeting station resource goals and objectives. Information from all stations was summarized and information relating specifically to prairie reconstruction issues was condensed.

Thirty-seven stations specifically mentioned prairie reconstruction issues. Many stations (22) have already reconstructed prairie sites totaling >95,563 acres. The 37 stations also estimated there are >101,271 additional acres that need prairie reconstruction.

While this survey was being conducted, two native prairie adaptive management projects were taking place – *Native Prairie Adaptive Management Project* (NPAM) and the *Grassland Monitoring Team* (GMT). Participants in these studies were happy with the results from these projects and wanted to know when a similar approach would be available to apply to reconstructed prairies.

After reviewing the report from the site visits and hearing from the participants of the native prairie projects, regional leadership identified prairie habitats and grassland birds as monitoring priorities for Region 3. Rick Schultz, Regional Chief of Refuges, approached the DBR and tasked the Inventory & Monitoring (I&M) Team to address this priority. A small team of refuge staff was charged with planning a workshop to define the issues and scope future work. Melinda Knutson, Jessica Dowler, Becky Esser, Cami Dixon, Pauline Drobney, and Sara Vacek worked on this planning team. The team worked on a problem

statement and identified the need to contract with a modeler to participate in planning and in the workshop. Jill Gannon was engaged via contract to fill this role. Regional leadership approved the initial problem statement and provided approval for holding the workshop. The problem statement and workshop plans were presented to the Prairie Biology Network and they agreed with the direction the group was headed.

Problem Statement

Tallgrass prairie originally covered approximately 240 million acres. Only 3% of the original tallgrass prairie remains as most of the prairie was converted to agriculture during the last 60-70 years of the 19th Century (Smith 1990). The vast majority of the acres lost were in the eastern portion of the tallgrass region. States exhibiting major losses include Minnesota, Illinois, Missouri, and portions of Wisconsin and Indiana. Tallgrass prairie is now meeting its demise in the Dakotas, Nebraska, Kansas, and Oklahoma (Faber et al. 2012). Virtually all tallgrass prairie in Iowa is gone, with less than 0.1% remaining (Smith 1990).

Reconstructing prairie is more critical today than ever, in light of recent trends in habitat loss across the upper Midwest. Reconstructing prairies is a goal for many Refuges and Districts in Regions 3 and 6 as identified in Comprehensive Conservation Plans (CCPs) and Habitat Management Plans (HMPs) and supported by the Biological Integrity, Diversity, and Environmental Health (BIDEH) Policy (601 FW 3). Therefore, a major activity of these Refuges and Districts is reconstructing native tallgrass prairie and managing those lands for station focal species, grassland-dependent birds and other wildlife.

However, managers and biologists have many questions on the most cost-effective ways to establish and manage prairie reconstructions for the greatest wildlife benefit. When asked, managers and biologists stated some of the greatest uncertainties related to prairie reconstruction included: influence of soils/other abiotic factors, best seed mix and rate, seeding methods including timing, weed management, and triggers for moving the reconstruction from establishment to maintenance phase. Not only are there many uncertainties related to reconstructing prairies, there are many limitations to implementing or expanding a prairie reconstruction program as well. The number one limitation agreed upon by most was money, followed by the staff-time needed to implement follow-up management. Additional limitations included accessibility of equipment that fit station needs, the availability of a local seed source, and inadequate training of staff and volunteers. Given the vast number of uncertainties, compounded by resource limitations, cost-optimization must be at the forefront of any decisions made related to reconstructing prairies.

As manager and biologists we can learn more quickly by pooling information and ideas, assembling the facts, using science to drive our decisions, and combining our monitoring resources, thus reducing the burden of work for an individual station rather than by working separately. Currently, we feel we are not being effective in meeting our prairie reconstruction goals and to remove these concerns we must reduce uncertainty in our reconstruction actions.

SCOPING CALLS

The Planning Team held a series of scoping calls to make sure the workshop focused on issues of concern to land managers working on prairie reconstructions. Biologists and managers across Regions 3 and 6 participated in discussions of their issues, concerns, and questions about prairie reconstructions. During each call, five questions were posed to the group:

1. What is your definition of a successful prairie reconstruction (i.e. what are your objectives for reconstructed prairie)?
2. If a reconstruction is unsuccessful, what are your thoughts on the cause?
3. What information would help you do a better job in prairie reconstruction?
4. What other limitations exist for initiation or expansion of prairie reconstruction?
5. If we were able to monitor 3-5 components of prairie reconstruction, what would be your priorities?

A total of 14 people participated in the calls; six addition people responded by email. Becky Esser compiled all of the responses from these calls (Appendix A).

WORKSHOP PLANNING

The planning team selected November 26-30, 2012 at Neal Smith NWR as the dates and venue for the workshop. Because we used structured decision making to organize the workshop, the team tried to keep the participants to 15 or less. Selecting participants was the most difficult task of the planning team because they wanted to ensure a variety of experience, different roles and broad geographic representation. The planning team also decided to include outside partners and academic professional from the beginning as they realized other agencies/groups have similar prairie reconstruction questions. It was also important to the planning team that upper level management participated to gain support. The team made a list of individuals they thought should attend the group either because of their experience or because they would fill ones of the roles identified by the team. The team also spent time meeting with other biology networks in Region 3, sending out emails and talking to individuals who were interested in the outcome of the workshop. After

going through this process the group came up with a list of 24 individuals and 21 of those were able to make it to the workshop.

List of Participants

1. Kristine Askerooth – Wildlife Biologist, Tewaukon National Wildlife Refuge (NWR)
2. J.B. Bright – Wildlife Refuge Specialist, Morris Wetland Management District (WMD)
3. Cami Dixon (Planning Team) – Region 6 Prairie Zone Biologist, Chase Lake NWR
4. Andrew DiAllesandro – Private Lands Biologist, Illinois Private Lands Office (PLO)
5. Jessica Dowler (Planning Team Co-Lead) – Field I&M Wildlife Biologist, Glacial Ridge & Rydell NWR
6. Pauline Drobney (Planning Team, Host) – Region 3 Prairie Zone Biologist, Neal Smith NWR
7. Rebecca Esser (Planning Team Co-Lead) –Wildlife Biologist, Detroit Lakes WMD
8. Kristin Fritz – Wetland District Manager and Assistant NWR manager, Big Stone NWR/WMD
9. Jill Gannon (Planning Team, Modeler) – USGS-Northern Prairie Wildlife Research Center, Jamestown, SD working from Athens, GA
10. Bill Johnson – Natural Resource Biology, Iowa Department of Natural Resources (DNR)
11. Steve Kahl – Project Leader, Shiawassee NWR
12. Kyle Kelsey – Wildlife Biologist, Madison WMD
13. Melinda Knutson (Planning Team, Facilitator) – Region 3 Inventory & Monitoring Coordinator, LaCrosse, WI
14. Diane Larson – Research Scientist, USGS Northern Prairie Wildlife Research Center, Jamestown, SD working from St. Paul, MN
15. Lisa Schulte-Moore – Professor, University of Northern Iowa
16. Tom Skilling – Wildlife Biologist, Union Slough NWR and Iowa WMD
17. Caitlin Smith – Private Lands Biologist, St. Croix WMD
18. Sarah Vacek (Planning Team) – Wildlife Biologist, Morris WMD
19. Tim Van Norman – Chief Branch of Permits, USFWS Washington Office, On detail in Ft. Collins office
20. Karen Viste-Sparkman (Host) – Wildlife Biologist, Neal Smith NWR
21. Gwen White – Science Coordinator, Eastern Tallgrass Prairie & Big River Landscape Conservation Cooperative

Participants Unable to attend

1. Randy Arndt – Grand River Grasslands Site Manager, The Nature Conservancy
2. Daryl Smith – Professor, University of Northern Iowa
3. Matt Sprenger – Refuge Supervisor, USFWS Region 3

Structured Decision Making in Reconstructed Prairies

When the workshop commenced in late November, for many participants it was their first experience using the Structured Decision Making (SDM) process to work through an issue.

So that everyone was on the same page and understood how we would be using SDM that week, Melinda Knutson gave a presentation on the background of the process and also share how SDM and adaptive management (AM) have been used in similar projects.

Major points from this presentation are:

- SDM is about good decision making and it helps managers do this
- The SDM process helps to –
    - Analyze a decision by breaking it into components
    - Find where there are obstacles and impediments
    - Break down the problem & identifying values
- The PROACT model from Hammond et al.'s book *Smart Choices: A Practical Guide to Making Better Life Choices* (1999*),* are the steps followed during the SDM process
    - Pr – Define the Problem
    - Objectives
    - Alternatives
    - Consequences
    - Trade-offs
- Working through the process helps decision makers define -
    - Fundamental Objectives – this is what we really care about, similar to a goal; Means objectives – a subset of objectives that when achieved help us meet our fundamental objective
    - Management Alternatives – a brainstorming session that develops list of alternatives to solve the problem
    - Influence Diagram – A figure with the fundamental objective on the right side of the working space, everything (control and uncontrolled) that has an effect on the fundamental objective is on the left and arrows are drawn to show how all the components are connected
    - Objective Hierarchies – Lines up the fundamental and means objectives and allows you to show what is important to you under each objective. This helps develop measureable attributes for each objective.
- SDM is an iterative process so each PrOACT step is revisited many times throughout the process
- SDM allows us to do a better job of institutional record keeping as to why particular decisions are made and what management decisions were applied.
- The ideal number of participants for an SDM workshop is 6-9 individuals; but SDM can be done with just one person at a desk in just one hour and can be used for working through issues of any size
- SDM can be used for one time decisions (e.g., should we list a species?) and adaptive management (AM) is used to address decisions that need to be made time and time again (e.g., would a particular unit benefit from a prescribed fire in year x, year x+1, etc.?)
- AM is a special case of SDM used for making recurrent decisions; The point of AM is to lower the uncertainty in the decision-making processes
- Monitoring is a key component of AM

- Monitoring can be costly and time-consuming but good planning pays off
- Make sure you have the resources to sustain the monitoring over time – including changes in budget and staffing

Next, Jill Gannon gave a presentation on a successful adaptive management project currently underway in Regions 3 and 6. The project is called the *Native Prairie Adaptive Management project (NPAM)* and is an excellent example of how the structured decision making process was used to develop a useful adaptive management project to manage native prairie sites in the Midwest.

These are the main take-away points from Jill's presentation:

- *Coordination*: it is important to stick to timelines and the standardized process; everyone must understand their roles and responsibilities; there must be continuous communication
- *Commitment to the process*: everyone needs to adhere to protocols; there needs to be time for learning to unfold
- *Multi-partner participation*: management realities/partner democracy → participation → learning
- *Leaders and champions*: need support from higher level positions

Sara Vacek then gave a presentation on another successful adaptive management project in Minnesota that is being used to manage native prairies. This project, called the *Grassland Monitoring Team* (GMT), used the same processes as NPAM to develop a monitoring protocol and models to help managers make better decisions when managing native prairies.

These are the take-away points from Sara's presentation:

- Defining objectives is SO important, and also harder than expected; need to devote enough time and energy to this step of the process
- Structure and transparency associated with the SDM process is very satisfying; it makes the decision-making process more robust; SDM increases confidence in the end decision
- SDM allows better communication about the decision-making process with the public
- Joint-learning/collaborative processes is powerful, but communication throughout the process is key

DEFINING THE PROBLEM

The planning team had developed a problem statement prior to the workshop. However, it was important to revisit this and agree on the problem as defined in the statement. There was general agreement from the participants that the issue we wanted to deal with was – "we feel we are not being effective in meeting our prairie reconstruction goals and to

remove these concerns we must reduce uncertainty in our reconstruction actions." The geographic scope for this project is US Fish and Wildlife Service Regions 3 and 6 although it is not limited to USFWS stations. Decision makers are conservation land managers with the USFWS, state or county agencies, and non-government agencies (e.g., TNC). The temporal scope is yearly monitoring during the establishment phase (years 1-3 or 1-5). Because of the wide range of experience and sites the participants work with, sites can range from 0.5 acres to 1200 acres, but on average, restoration sites are about 40 acres in size.

SETTING OBJECTIVES

To begin the process of defining objectives, the group did an exercise and created an influence diagram. The fundamental objective was to "Reconstruct a healthy prairie". We built the influence diagram below that aided us in defining our means objectives. Two strategic objectives were also defined – 1. Meeting policy expectation (i.e., USFWS – Biological Integrity, Diversity and Environmental Health Policy [BIDEH]) and 2. Provide ecosystem services to society, especially clean water and carbon sequestration.

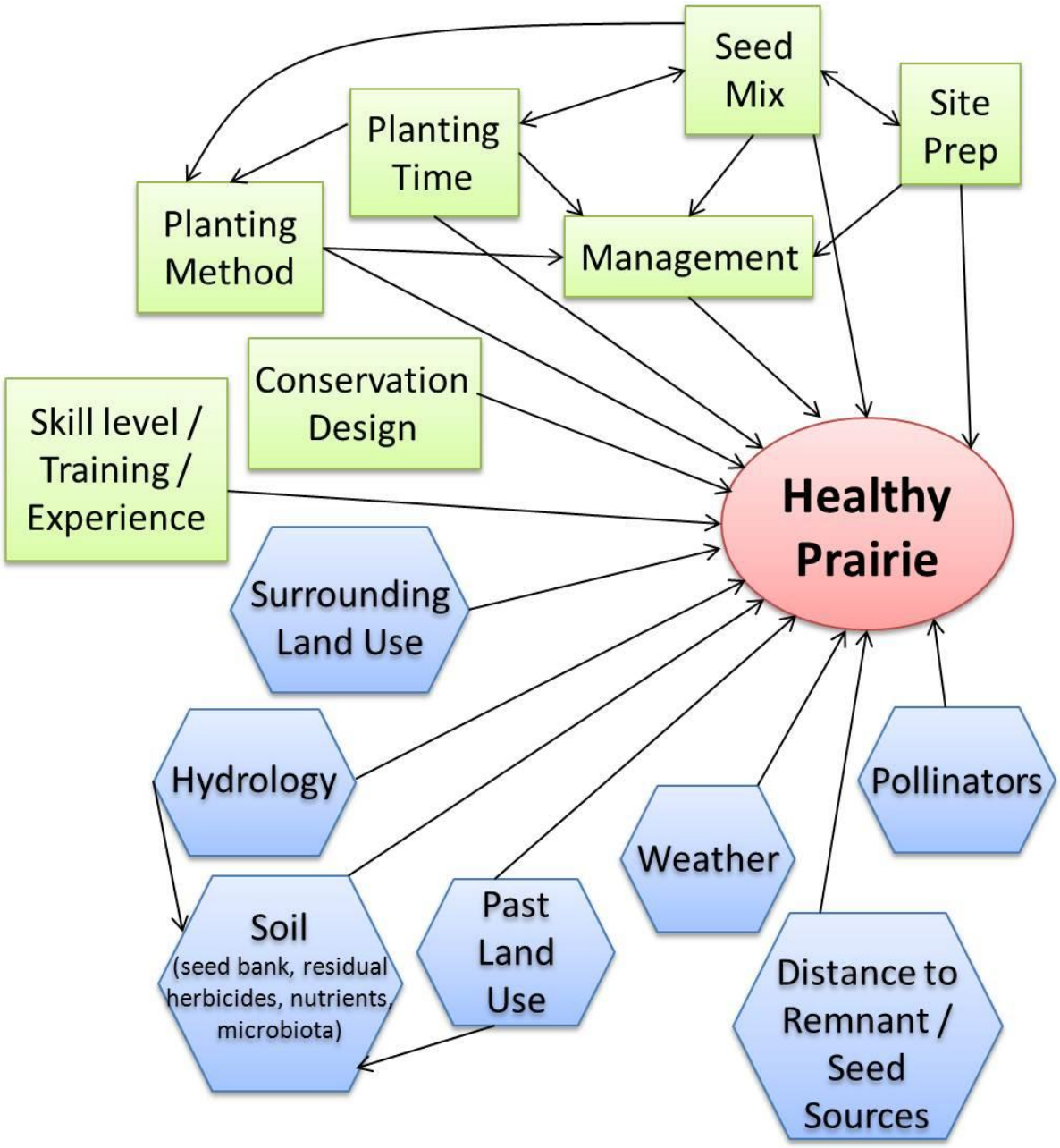

FIGURE 1. INFLUENCE DIAGRAM – 'Reconstruct a Healthy Prairie' is the fundamental objective. All other items have an effect on the success of reconstructing a healthy prairie. Items in green rectangles are elements we have some control over (potential actions) while items in the blue hexagons are elements we do not have any control over (chance events).

After the influence diagram was constructed, participants were able to visually see all the elements that have an influence on our ability to reconstruct a healthy prairie. The

objectives were then stepped down to the following objective hierarchies. An objectives hierarchy helps define measureable objectives.

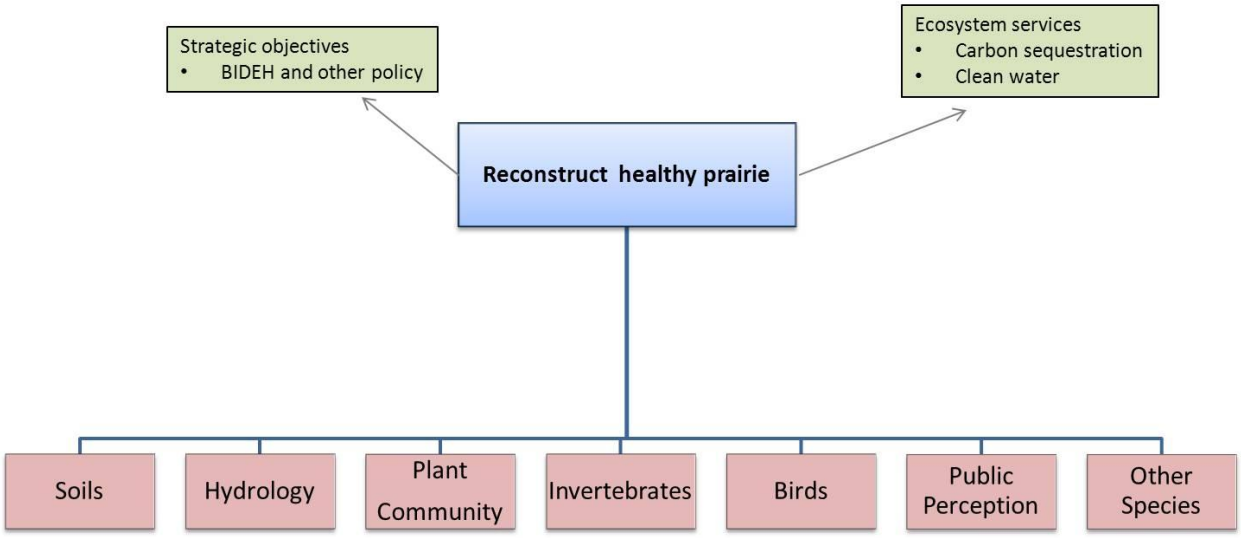

FIGURE 2. OBJECTIVES HIERARCHY – this diagram identifies 'Reconstruct a healthy prairie' as our fundamental objective, while all the items in the pink boxes are the means objectives. Each of the means objectives is further broken down in the following figures. The two green boxes tied to the fundamental objective were identified as strategic objectives.

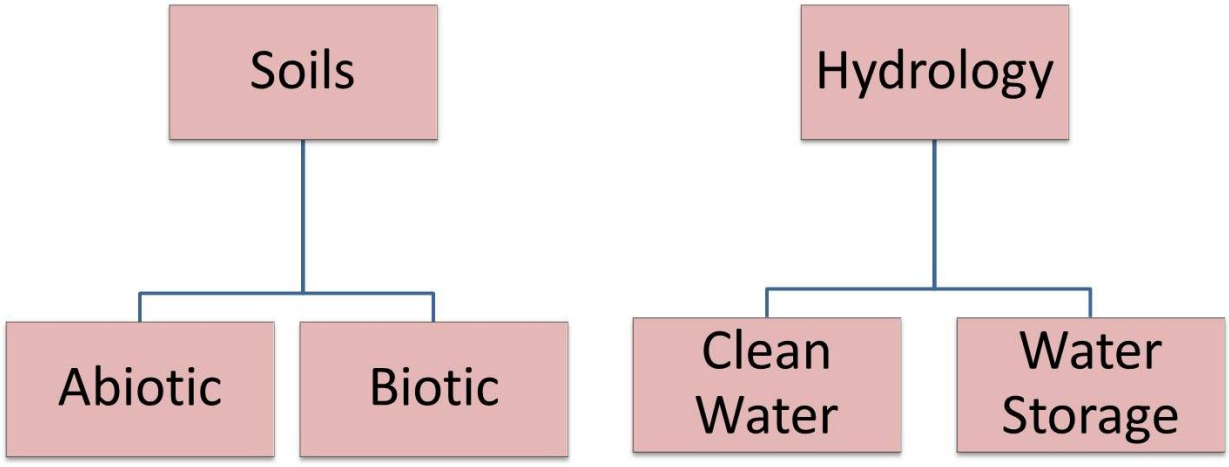

FIGURE 3. SOILS AND HYDROLOGY MEANS OBJECTIVES – There are both abiotic and biotic components that are important qualities that make up a soil profile. Having clean water and providing water storage in a reconstructed prairie will help meet hydrological objectives.

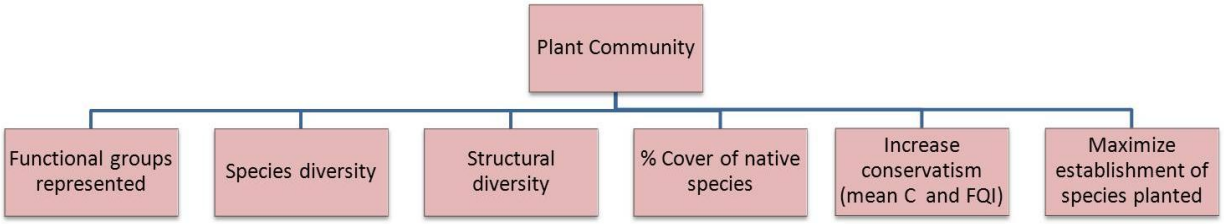

FIGURE 4. PLANT COMMUNITY MEANS OBJECTIVES – there are many components that must be taken into consideration to meet plant community objectives. Functional groups can include, but are not limited to, phenology (bloom time, c3/c4, etc.), root system, and the mosaic of groups across a landscape.

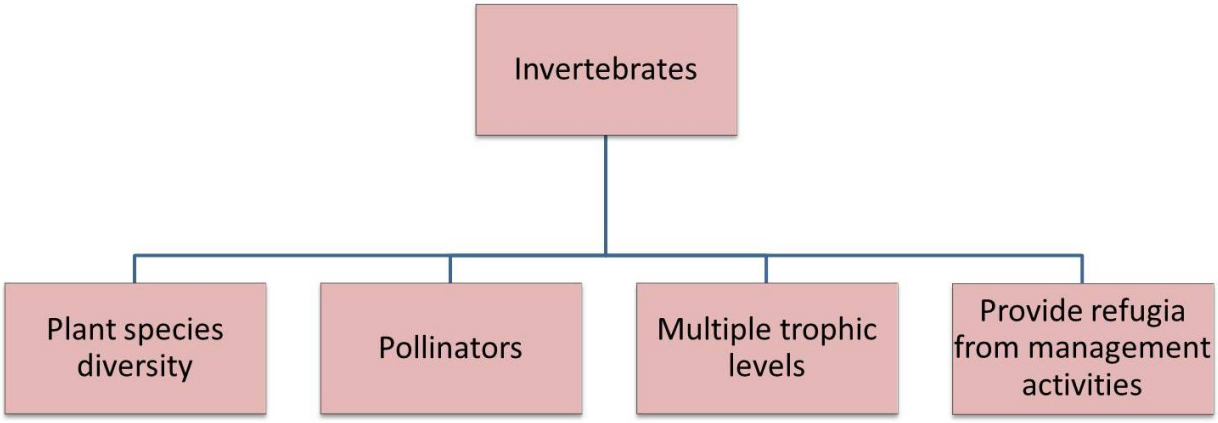

FIGURE 5. INVERTEBRATE MEANS OBJECTIVES – to ensure the invertebrate means objective is met, it is important there is plant species diversity, the proper native pollinators, multiple trophic levels to support a diverse invertebrate community, and invertebrates have refuge from management activities (e.g., mowing, prescribed fire).

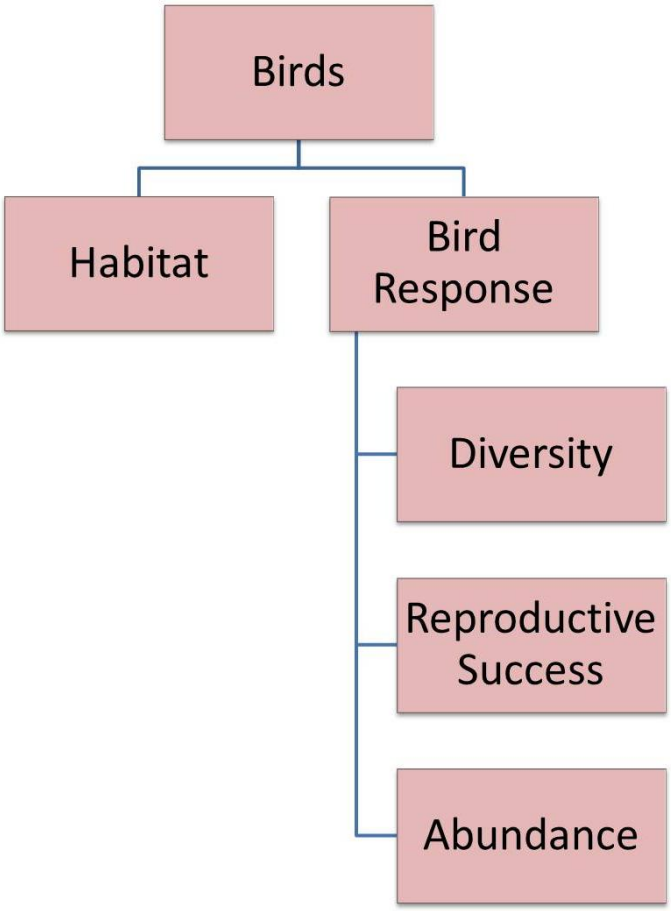

FIGURE 6. GRASSLAND BIRDS MEANS OBJECTIVES – for birds to be successful in reconstructed prairies, the proper habitat must be available and their responses to that habitat (diversity, reproductive success, and abundance) must be positive.

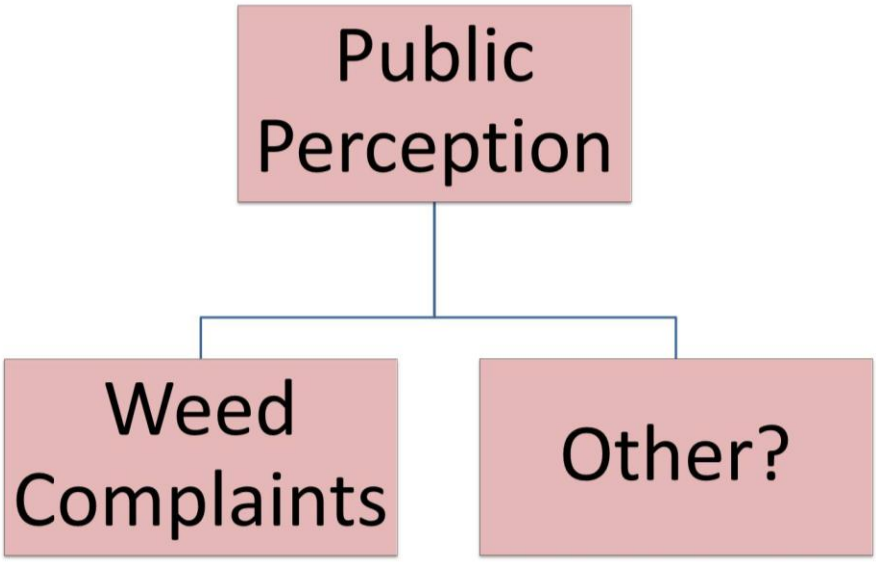

FIGURE 7. PUBLIC PERCEPTION MEANS OBJECTIVES – weed complaints are a normal part of the reconstruction process although it is important to keep those to a minimum.

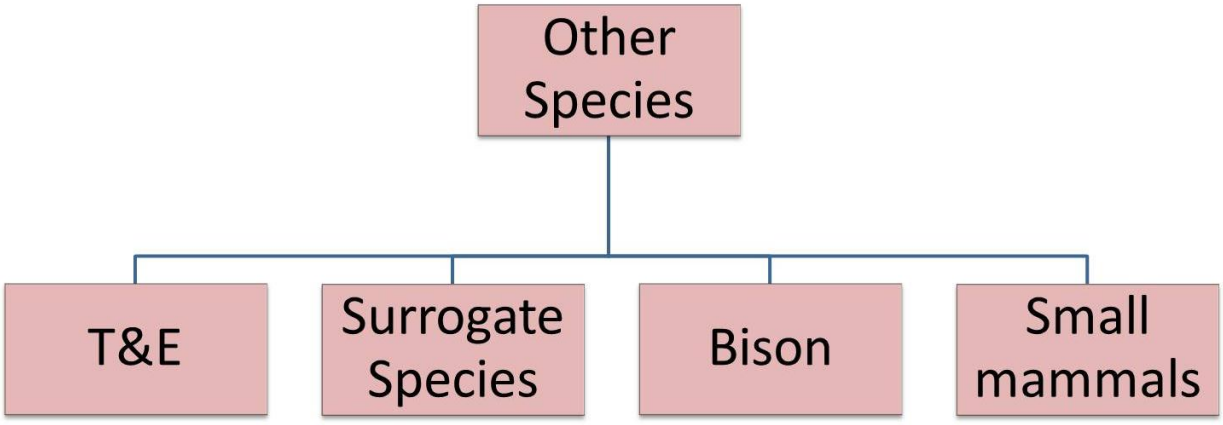

FIGURE 8. OTHER SPECIES MEANS OBJECTIVES – there are many wildlife species besides birds and invertebrates that are an important component of a healthy reconstructed prairie. Threatened & Endangered species, surrogate species, native prairie animals (such as bison) and small mammals are all integral pieces of a healthy prairie.

To put a value on the means objectives, the group went through an exercise to help identify what is most important to us and why we reconstruct prairies. The means objectives were written on a board and we were asked to place stickers next to what was most important to us. These are the results of that exercise:

- 54% - maximize native plant establishment
- 19% - Promote suitable habitat for inverts
- 13% - Provide suitable habitat for grassland associated birds
- 10% - maximize public acceptance of prairie reconstructions
- 4% - Promote suitable habitat for other animals (threatened & endangered species, prairie endemics, etc.)

The participants were broken into 5 groups (plants I & II, invertebrates, grassland birds, and public perception). Each group came up with a list of measureable attributes for each of the top 4 objectives and the unit used to measure that attribute. These are examples that may be used in further steps to identify measurable objectives.

TABLE 1. PLANTS I GROUP – This group focused of defining measureable attributes and units for vegetative cover, C values (Conservatism), and species establishment and resilience. The group also came up with three potential measureable objectives.

Measure	*Unit*
Objective: Increase cover to 75% native in 3-5 years	
Native cover	%
Native species diversity	% frequency
Objective: % of known species mix established by X year	
3 year target = 50%; 5 year target = 75%; 7 year target = 90%; measure with transects	%
Objective: Increase Coefficient of Conservatism; goal: 90% CC of known mix	
measure with transects	What percent of known mix is reasonable? To test this start with a range of mixes

TABLE 2. PLANTS II GROUP – This group determined measureable attributes and possible data collection methods for plant functional groups, species diversity, and structural

diversity. This data can be collected once a year later in the growing seasons OR twice a year-once early in the growing season and once later in the growing season.

Measure	*Methods*
Objective: Maximize species diversity and functional groups	
Presence/absence (with checklists)	Plots Transects Wandering search Point intercept
% cover – basal, aerial	
Stem counts	
Indicator species	
Functional groups	
Structural diversity	Plot Transect
Visual Obstruction Reading (Robel pole)	
Litter depth	
Photopoint	
Shrub cover	
Bare ground	
Height	

TABLE 3. INVERTEBRATE GROUP – This group came up with three objectives related to providing for successful invertebrate populations in a reconstructed prairie. For each of those objectives, they defined at least one measurable attribute and unit. The group also had one major question related to invertebrates – "If we build it, will they come?"

Measure	*Units*
Objective: Provide diversity of flowering native plants throughout growing season	
Native flower diversity - Early, mid, late seasons	Low, medium, high
Flower diversity color	
Flower diversity shape	
Objective: Provide diversity of wintering nesting habitat	
Woody debris	Presence/absence Or low, medium, high
Bunch grasses	
Bare dirt	
Objective: Provide refuge from management activities (burning, haying)	
Unmanaged habitat in any given year; ≤60% per year	Percentage

TABLE 4. BIRD GROUP - This group knew that to have a healthy grassland bird population, suitable habitat must be available for birds and certain bird population metrics must be achieved. Measureable attributes and units were identified for both of these objectives.

Measure	*Units*
Objective: Provide suitable breeding (nesting?) habitat for grassland birds	
Litter depth (range of depths across the unit)	cm
Vegetation structure	dm
Plant height	cm
Species composition	% frequency
Distance to nearest tree	meter
Block size	ha
Distance to water	meter
Wetland complex	Type
Objective: Bird measures	
Nest density	#nests/ha
Nest success	Mayfield/mod.
Pair density	#/ha
Brood counts	#/ha
Singing male density	#/ha
Lek counts	# leks/unit, # males/lek
Species richness	# and presence/absence

TABLE 5. PUBLIC PERCEPTION GROUP – This group came up with three objectives, measureable attributes and units that will help meet the public perception objectives.

Measure	*Units*
Objective: Minimize weed complaints and increase the number of compliments	
Complaints	#
Objective: Foster understanding with key targeted audiences (weed boards, congressionals, private landowners)	
Amount of participation & communication	# participants at meetings
Objective: Foster understanding with general public	
Positive/negative responses to survey	Proportion of negative to positive responses to surveys

ALTERNATIVES

When reconstructing a native prairie, there are usually seven steps that occur. These seven steps are:

1. Site nomination (what to reconstruct) – this is how a site becomes available for reconstruction. This can be done through conservation design (e.g., prairie plan), new acquisitions, and landowner contacts.
2. Site assessment (what parcel to invest in) – Should we restore the site? This is done through prioritization, conservation design, and landscape context.
3. Site selection & analysis – when to reconstruct (e.g., in a year, season)? During this step it is important to gather information to determine how the site should be restored. This is the step that has been done inconsistently in the past. Important factors to assess in site analysis include - topography, soils (soil type, pH, level of erosion, and micro-biota), water table, existing vegetation, land use history, seed bank, landscape context (surrounding land use, proximity to native and reconstructed prairies), and nutrient analysis. The group agrees there is a need for a "standardized protocol" for site analysis that can be used for any reconstruction.
4. Seed selection
5. Site preparation
6. Planting method

7. Post-planting management

After some discussion, the group decided that in most cases there are not many management decisions in the first three steps. Many times our decision to reconstruct a prairie has been pre-determined when a site is purchased, donated to an agency, or a willing landowner steps forward. The group also decided that most questions or uncertainties are in steps 4-7 of a reconstruction and that is where we should focus our efforts at the workshop. To develop a list of management alternatives for each of the last 4 steps, the participants were split into 4 groups. Each group presented their list of alternatives to the larger group.

SEED MIX ALTERNATIVES

TABLE 6. Seed Mix Alternatives - *Seed selection may be influenced by the major invasives present (ex: reed canary grass).

Decision	*Alternatives*	*Comments*
Do we use harvested seed or purchase seed from a vendor?	1. use purchased seed only 2. use harvested seed only 3. use a combination of purchased and harvested seed	Purchased seed is usually clean without extra chaff. Harvested seed usually has large amount of chaff along with the seed. The equipment available to you for harvesting and planting could be the decision-maker during this step.
Do we use seed that is tested or not?	1. use purchased seed that is tested 2. use harvested seed and send it in to have it tested for PLS 3. use harvested seed and estimate PLS 4. use harvested seed without any testing	Purchased seed always comes tested for Pure Live Seed (PLS). Whether harvested seed is tested for PLS or not is up to the decision-maker.
What is the forb-to-grass ratio?	1. low – 25:75 2. medium – 50:50 3. high – 75:25	
What is the cool-to-warm season ratio?	1. low – 10:90 2. medium – 33:66 3. high – 50:50	
What is the conservative-to-non-conservative ratio?	1. low – 10:90 2. medium – 33:66 3. high – 50:50	Conservative: C-value 5-10, non-conservative: C-value 0-4

Decision	*Alternatives*	*Comments*
Do we use sculpted or one-size-fits-all seed mixes?	1. using different mixes on different parts of the unit to match micro-habitat or other conditions 2. use a single mix over entire unit	
Do we use spiked planting to deter invasive species (e.g. Canada thistle) or not?	1. business-as-usual mix plus spiked planting 2. business-as-usual mix	
Should we do phased planting (mixes planted in different phases of reconstruction) or 1-shot plantings?	1. the unit is planted at different phases (usually in different years) of reconstruction 2. the entire unit planted at one time	Planned *a priori*, not in response to a failure of some species to be expressed, i.e. planting aggressive or pioneering species only in the beginning and phase conservatives in later. Most are doing 1-shot plantings.
Do we use a mix that includes hemi-parasitic plants or not?	1. a mix including hemi-parasitic plant species 2. business-as-usual mix	Most prairie seed mixes do not currently include hemi-parasitic plant species
Should we use a mix designed to support prairie dependent invertebrates and invertebrates of concern (e.g., pollinators) or not?	1. mix with a larger amount of forbs and other plants that benefit invertebrate life requirements 2. business-as-usual mix	
Should we plant both seeds and seedlings or plant only seeds?	1. business-as-usual mix plus seedlings 2. business-as-usual mix	
Should we attempt to design species mixes resilient to climate change or not?	1. seed mix expected to favor resilience and anticipated climate change conditions 2. business-as-usual mix	

SITE PREP ALTERNATIVES

Goal: To have a firm seed bed and maximize seed to soil contact; removing residual biomass and killing undesirable plant species may be necessary.

The planting method is dependent on the state of the site (crop stubble, black dirt, or into existing exotic vegetation), what type of equipment is available for planting, land management history, seed mix type, and desired result. Decisions are linked and can be made moving forward or backward through this process. For example, you may need to go back and re-evaluate your seed mix when you know more about the state of your site (black dirt vs. standing brome) and the what equipment is available for planting (if you only have a drill for seeding, you would not pick a mix with a lot of chaff).

TABLE 7. SITE PREPARATION ALTERNATIVES – the first two alternatives are based on the state of the site, the remaining decisions are alternatives that were identified in the first two decisions but grouped sub-alternatives under these.

Starting states	*Alternatives*	*Comments*
Starting with black dirt/crop stubble	1. Disking/packing 2. Burning 3. Planting a nurse crop 4. Restore hydrology 5. No action	Planting a nurse crop is most likely to be used if there is a high amount of residual nutrients in the soil that could negatively impact a seeding, or where exotic species threaten ultimate success of the planting
Starting with existing perennial vegetation (brome or CRP planting)	1. Interseed 2. Farming/cropping 3. Tillage 4. Grazing 5. Burning 6. Haying 7. Mowing 8. Herbicide/chemical 9. Combo (herbicide and tillage) 10. Weed control 11. Restore hydrology 12. Woody plant removal 13. Defoliation (Grazing, Burning, Mowing, Haying) 14. No action 15. Combinations of above	Can have few natives, or be near monoculture of cultivar natives, for example.
Exotic species exist; control needed	1. Herbicide 2. Tillage 3. Cropping 4. Tree control 5. No action 6. Combination of above	

Starting states	*Alternatives*	*Comments*
Excessive duff and residual biomass exists.	1. Burn 2. Graze 3. Mow 4. Hay 5. No action 6. Combinations of above	
Soil chemistry damaged; needs adjustment	1. Cropping 2. Plant surrogate plant species to change chemistry prior to prairie reconstruction 3. Burn 4. Combinations of above 5. No Action	
Hydrology damaged; needs repair	1. Fill ditches 2. Break tile 3. Combinations of above 4. No action	

PLANTING METHOD ALTERNATIVES

Table 8. PLANTING METHOD ALTERNATIVES

Decision	*Alternatives*	*Comments*
Broadcast seeding - timing	1. Dormant (after dormancy in fall on bare soil, post-burn ash, or over the snow) 2. Spring (after dormancy breaks) 3. Summer (not recommended – can work but very dependent on soil moisture)	
Broadcast seeding - method	1. Heavy equipment 2. User grazers (hoof action delivers seed to soil in existing grass) 3. Hand seeding 4. Hay prairie and roll out/blow hay onto the host unit 5. Packing or not	Controllable factors: timing, delivery, rate, packing (w or w/o); Can be easier with bulk seed, less cleaning required so ensures more sizes of seed are retained in the mix
Drill - timing	1. Spring (bare soil, post-herbicide residue)	Controllable factors: timing, rate, depth of planting

Decision	*Alternatives*	*Comments*
	2. Fall 3. Summer (not recommended unless it is a very wet season)	
Combos	1. fall broadcast forbs + fall drill grasses 2. fall broadcast forbs + spring drill grasses	
Animal seed dispersal		On the fur of bison, for example.
Plugs and monoliths	Transplant prairie plants from existing sites.	This would require a lot of work for large blocks of soil

As the 'Planting Method' group presented their list of alternatives to the group, there was a lot of discussion about the techniques involved. Jill took everything that was said and approached the alternatives slightly different than group did. Her take on these alternatives is included below:

JILL's version of planting method alternatives:

Broadcast w/o packing
- Timing – dormant, snow, spring
- Delivery – machine, hand
- Rate – low, medium high (?, 40, 80)

Broadcast w/ packing – grazing, machine

Drill
- Timing – spring, fall
- Rate – low, medium high (?, 40, 80)

Combination
- Timing – fall broadcast (B) forbs + fall drill (D) grass, fall B + spring D

Animal dispersal

Plugs/seedlings/monoliths

DISCUSSION

- Bill doesn't see much difference in success between broadcast seeding and drilling per say; the difference is operator error
- Karen: An interesting side note, Pete E.'s work on bison seed dispersal
- Kyle: Ag is advancing so much with regards to residue management; we're going to have to change as well
- Becky: Planting over snow; what are the advantages?
- Bill: You can see where it goes so you can take care of misses.
- Pauline: Are there fewer or more seed predators in winter planting?

- Is clean seed worth the cost? It often misses small seeds, invertebrates, and diseases.
- Dormancy: If seed of a species like needlegrass (*Stipa spartea*) is not planted immediately, it can go into double dormancy. Needlegrass is said to have the ability to go into a deep dormancy of up to 7 years. For such species, it is best to harvest and spread right away.
- Melinda: So much going on here, perhaps move towards a set of scenarios instead of a set of management alternatives. We've got Bill's scenario, Steve's scenario, Pauline's scenario, etc. We could represent managers' mental models through scenarios.
- Tim: I wonder if this would be better organized by question; kind of like a user manual's trouble shooting guide.
- Becky: Larry Hanson has already done something like this. This could be updated and revised for these purposes.
- Caitlin: Updates could be managed through Google Docs.
- Pauline: Loads of information already out there. How do we organize it?
- Jill: Decision tree would be useful, but in this case it would explode fairly quickly. Decision software is out there that could be helpful (Netica). It is not good for repeated decisions but is good for one-time and linked decisions.
- J.B.: This is simpler than we're making it: Everything we do, we're trying to maximize seed-to-soil contact.
- How many people use the 40 seeds/ft2 target for species? Answers: ~1/2 of managers. Where did this target come from? Practical knowledge: Neal Diboll out of Westfield, WI; that's what he found worked well – anything less didn't seem to compete well against weeds; was used in early seed mixes at Neal Smith and other places. Don't know if this was the origin, but very well could be.
- J.B.: With regard to seed mix, he tries to minimize the number of seeds of aggressive native grasses.
- Bill: Yes, but these also provide good ground cover while more conservative species take time to establish.
- Steve: Strongly considers species that are good competitors with reed canary grass.
- Pauline: Could compare seed mixes (different species identities) with regards to competitiveness with invasives.
- Cami: May want to vary the planting density with regards to competitiveness against invasives.
- Thoughts –drill and broadcast both work, *operator error is biggest concern*
- Drop seeder should be used if there is not firm seedbed with broadcaster (does same thing as cultipacker)
- We are seeing more and more residue from crops, so will need to adjust seeding method
- Seeding rates – 20 bulk lbs. per acre (about 8 Pure Live seed [PLS] lbs. per acre)
- Legumes can shatter when cleaning seed. You can lose small species in cleaned seed as well. Think of all of this going through hammermill multiple times as you clean, it is destructive to seed.

- Possible action item – how are you doing your seeding and why do you do it that way? Write up scenario book that has documentation of what and the way everyone is everyone doing it. Also if we have enough history on some sites we could put into some type of document.
- How to group all of this: timing, delivery, seed selection, rate (typical seeds per sq. foot = 40;)?
- It would be useful to have a spreadsheet tool – that has functional groups, rate, and kicks out forb to grass ratios thinking aggressive vs. conservative
- Rate – general guideline is 40 PLS per sq. foot. Could go with higher as an alternate option (80?). Rate will depend on seed mix and seeding method. Broadcast requires (e.g., in ND) 1.5X more seed than for drilling. Clean seed vs. bulk seed (so use PLS instead of direct weight). 40 seeds/sq. ft. – common knowledge? Where did that number come from? ***lit search need could really influence cost
- Other considerations –
    - Goal for any of our seeding approaches is to maximize seed to soil contact, best technique depends on the site conditions, seed mix, etc. but that's the goal.
    - Patchy seeding may allow opportunity for inter-seeding.
    - Can be operator error and equipment issues with drill or broadcast.
    - Some other equipment options like drop seeder, broadcast seeder with packer built in, bale blower
    - Loosen just before seeding with light harrow or rake drag.
    - Agricultural technology is changing so much, we will see more and more residue left on the field – we will have to adjust our techniques to deal with that extra biomass.
    - How seed is harvested and prepared (cleaned, run through hammer mill, dried or not, time in storage, etc.) affects seed to soil contact and germination success
    - Insects, fungi etc. that may be captured in combine or hay bales and transferred to a reconstruction – they would need something to live on until the prairie is established, so maybe incorporating this at a later date – interseeding insects.

POST-PLANTING MANAGEMENT ALTERNATIVES

Starting in the year following planting, there are numerous management alternatives available. Although the definition of a reconstruction going from establishment phase to the 'maintenance' phase was not decided upon, this group went to year 5 as this seemed sufficient to cover the establishment phase for most of the participants.

TABLE 9. POST-PLANTING MANAGEMENT ALTERNATIVES – While other alternatives may be possible during any year, these are the alternatives currently used at stations. Which alternative is chosen is dependent on the state of the site. During each year, any alternative or combination of alternatives may be used. It should be noted that not all alternatives

were considered each year, mostly because of logistical reasons (e.g., there is not enough fuel to carry a fire during year 1 and 2).

Yr 1	*Yr 2*	*Yr 3*	*Yr 4*	*Yr 5*
Rest	Rest	Rest	Rest	Rest
Mow once	Mow once	Mow once	Mow once	Mow once
When vegetation gets to 1 ft. mow back to 4-6" (multiple mowings per year)	When vegetation gets to 1 ft. mow back to 4-6" (multiple mowings per year)	When vegetation gets to 1 ft. mow back to 4-6" (multiple mowings per year)	When vegetation gets to 1 ft. mow back to 4-6" (multiple mowings per year)	When vegetation gets to 1 ft. mow back to 4-6" (multiple mowings per year)
	Spot mow for weeds	Spot mow for weeds		
		Burn spring - fall	Burn spring - fall	Burn spring - fall
	Spot spray	Spot spray	Spot spray	Spot spray
Hay	Hay	Hay	Hay	Hay
Graze (flash)	Graze (flash)	Graze	Graze	Graze
			Interseed	Interseed

Comments:

- A row (above) isn't a plan and any above alternative could be chosen in a given year. There are endless combinations and some may require another preceding or following treatment (e.g., interseed + hay)
- Mowing can be used for invasives control, but also for light and water availability to help increase diversity. It also manages root structure of more aggressive plants, especially grasses that can dominate a landscape. This could allow less competitive species a better germination and survival success rate.
- Mowing is often done because it's easy and is more flexible compared to burning and grazing.
- The root structure of plants is dynamic among and within a given year, and can be influenced by management.
- Typically a plan is in place for establishment phase management, but it is flexible based on state of the site and other conditions. (e.g., plan of action is to mow in year 1 – but that plan may change because of site conditions (wet), staff limitations, etc.)
- With haying you cannot cut as high as with just mowing, this could impact your results
- There are major state variables in managers' heads: soil type, average rainfall (ecoregion), wet vs. dry year, major invasive(s), amount of residual vegetation (fuel load) – we must learn how to capture this to do better management
- Which alternative you choose in a given year is a two stage decisions
    1. Where is the site?
        a. soil types
        b. invasive threats

c. ecoregion/avg rainfall

2. What is the state of the site?
   a. Dominant vegetation (desirable vs. undesirable, grass vs. forb)
   b. Weather patterns
   c. Amount of standing biomass
   d. Plant phenology
   e. Resources – staff time, equipment, money

- For example:

Year	*Dominant vegetation*	*Alternatives*
1	Canada thistle	Mow, rest, or spot spray
2	Natives	Rest, mow, hay, spot spray
3	Other weeds	Rest, mow, hay

UNCERTAINTIES AND QUESTIONS

Throughout the week, many questions and uncertainties surfaced. Some of the questions were recurring and brought up over and over, some were mentioned only once. Of the many questions that were brought up, this one seemed to capture many other uncertainties and was mentioned numerous times – 'Does a high cost planting regime that meets objectives lead to a lower cost long-term management regime?' Regardless of the number of times a question was posed to the group, it is captured below in its respective category.

TABLE 10. QUESTIONS AND UNCERTAINTIES – Below are all of the questions and uncertainties that were brought up during the workshop. The questions are broken up in to categories. The last two columns in the table are there to help the group decide which questions we can answer and how we might approach it.

Phase	*Uncertainty*	*Is it reducible?*	*How should we address?*
Overall	Does a high cost/effort (diversity and vigilance) planting regime result in low cost/effort long-term management?		
	How do we know when the establishment phase is over?		Definition needed
	How important is it to research the best prescription for a specific site? Is there an appropriate way to reconstruct a prairie? Or can some things be generalized?		
	How do we define *good enough* for the wildlife response we want to see?		develop better objectives
	How much diversity is enough for a sustainable prairie? What is a realistic objective?		develop better

Phase	*Uncertainty*	*Is it reducible?*	*How should we address?*
			objectives
	If we build it will "they" come? If we put the right plants in the ground, does the rest of the ecosystem come along (inverts, birds, soil biota, etc.)?		
	For the effort and money we put into reconstructions, are we satisfied with what we are getting back?		
	Will our efforts ever result in prairie or are we only putting grassland habitat on the ground?		
	There are dual purposes of increasing diversity and decreasing invasives. We need to identify the Achilles heel for some of the really bad invasives. Which invasives are worth spending a lot of effort and money controlling, and which are best managed by ensuring a healthy, diverse prairie? How do we avoid favoring the invasives?		
	With all the variables discussed – can we quantitatively measure if we are being efficient and effective with our reconstructions?		
	Is there so much noise in the system that we will always end up with different results regardless of management actions we take?		
Site Analysis	How do abiotics of reconstruction site (soil chemistry, seed bank, etc.) affect outcome of reconstruction? How do we use soil chemistry and nutrient loading information to plan a reconstruction? Should soil characteristics shape our management decisions?		
Seed Mix Selection	How diverse can we make a prairie with the least amount of money? Diversity is good but limiting factor is how much we can spend to get there.		
	Is there an appropriate seed mix that achieves minimum station goals?		
	What is the correct # of seeds/sq. ft.? Currently most are using 40 seeds/ft^2 as this is what was recommended by NRCS, but what data supports this recommendation? Has anyone tested this information recently to see if this rate should	Yes	research

Phase	*Uncertainty*	*Is it reducible?*	*How should we address?*
	change with improved reconstruction methods? How many species, how many seeds of each species, and how many seeds total?		
	What is the ideal ratio of grasses:forbs to ensure a resilient prairie?	Yes	
	What is the ideal ratio of cool:warm season species to ensure a resilient prairie?	Yes	
	What is the ratio of allelopathic, competitive, and hemi-parasitic species in a seed mix?	Yes	
	What is the ideal ratio of conservative: opportunistic species to ensure a resilient prairie?	yes	
	If you don't have the perfect seed mix, can we get there through management? How far can we push that approach?		
	Cool-season component – how does prairie function if a healthy cool-season component is present, related to suppression of exotics. Is it time to move beyond our tradition of warm-season dominated seed mixes?		
	How important is local ecotype? How local is local (mileage)? What are the implications for climate change and diversity/seed availability?		
	Is a local seed source more important than a diverse planting? What if you cannot do both?		
	Are there differences in the seed mix components (e.g., forb-to-grass ratio) for different geographic zones?		
	Is it worth doing high diversity vs. low diversity plantings? In terms of cost and wildlife benefit.		
	Is there a minimum # of spp that should be in a planting? (efficiency question)		
	Should we do sculpted seedings – different seed mixes for different parts of a reconstruction unit or use the same mix over the entire unit?		
	Is it possible or desirable to tailor a seed mix based on site conditions, dollars available, and objectives?		
	Pure Live Seed (PLS) – how much of what we plant is viable? To what degree do we need to		

Phase	*Uncertainty*	*Is it reducible?*	*How should we address?*
	know viability and purity to plan a seeding? RESEARCH QUESTION. Three "states of the seed": • Purchased, cleaned, tested seed • Harvested bulk, tested (but how accurate?) seed • Combination of bulk harvest and purchased seed		
	What is the minimum sample size you need to accurately portray purity and viability of collected seed?	yes	Research, lit search
Site Prep	What's the ideal method to prep a site for reconstruction? Is there one?		
	If there is existing perennial cover – should we interseed or till? Should we have a protocol for how to prep existing grass?		

	Are there soil characteristics (seed bank, chemistry, soil biota, carbon saturation deficit) that affect the outcome of a reconstruction? If so, should this influence how we prepare a site for reconstruction?
	• Should we plant a "nurse" crop?
	• How much does seed bank matter?
	  ○ Lots of invasives?
	  ○ Possible use of annual rye to "clean up" site?
	• What about soils matters – chemical, physical, and biological parameters?
	  ○ High N → suppression by legumes?
	  ○ Soil Organic Matter
	  ○ Do soil flora and fauna affect the outcome?
	• Soil Chemistry & biota – how do they affect outcomes
			Lit search

Planting Methods	No major uncertainties among this group		
Post-planting Management	What are the best post-planting mgmt. techniques and should I be using them to ensure a successful prairie recon at minimal cost		

Phase	*Uncertainty*	*Is it reducible?*	*How should we address?*
	Is success determined by our seed mix independent of our management?		
	What is the importance of Canada thistle control on the success of a prairie reconstruction?		
	To mow or not to mow? • Does mowing help or hurt thistle? • Does mowing promote seedling establishment (sunlight)? • Does mowing affect diversity? • Reasons not to mow: Doesn't make sense in the context of plant succession; every time you take the blade out there, you are affecting wildlife; helps trap snow so there's more moisture for the plants in the spring. • Reasons to mow: Weed control. Usually done for thistle control, but thistle loves light, so does it really help? In some cases, it's pretty clear and in others not-so-much.		

	Is it possible to reconstruct a prairie without the use of herbicides?
	• Should we use grass-selective herbicide to reduce dominance of grasses?
	• Is spot spraying required for a select group (EDRR species) of invasives?
	• Can we identify an Achilles heel for some of the really bad players?
	• How can we design our management to avoid promoting the invasives?
	• Broadcast spraying: would prefer not to use broadcast herbicide; rather have someone else prove that it is effective
	  ○ Be careful with Milestone, which is commonly used on Canada thistle; seems to have a detrimental impact on species not on their product list
	  ○ May use in the spring to kill weeds, if you are forced to plant in the spring		

Phase	*Uncertainty*	*Is it reducible?*	*How should we address?*
	○ May use grass-selective herbicide (Post, Select, fusilaide) to decrease the dominance of grasses in a new seeding? Doesn't seem to work with reed canary grass. • Spot spraying – back pack ○ Is spot spraying required for a select group of "nasties"? Which species are these? ○ Not a biological uncertainty; it's usually used as a political response in response to a complaint		
	Fire • When should you bring fire to a reconstruction? What is the trigger for that first burn? ○ As soon as a sufficient fuel load (ASAP)? ○ Early in establishment to promote establishment – some species require fire to release? ○ Wait longer so we don't hurt seedlings, or so we get some seed production first, or so we don't promote undesirable species? ○ Are there vegetative cues that indicate a problem that can be addressed by fire (e.g., woody species, overly abundant grass)? • Is the season of the burn important for the development of the planting (dormant vs. growing season, fall vs. spring)? • How often should a reconstruction be burned during the establishment phase?		Lit search
	Is high or low input (management) best? Can you get by with low input? Is high input better in the end?		

Phase	*Uncertainty*	*Is it reducible?*	*How should we address?*
	If we don't have an ideal seed mix, can we get there (meet objectives) through management? How far can we push that approach?		

PRODUCTS AND ACTION ITEMS

A list of desired products wanted from participants was pulled together from all of the discussions during the week. Also, on the last morning of the workshop the group went through an exercise of writing down one product they would like to see come out of the workshop. Most of these desired products go hand-in-hand with the uncertainties and would answer many of our questions. The list below is the compilation of all desired products from discussions and the exercise.

OVERALL

- Better definitions and benchmarks for prairie and prairie reconstruction (similar to what we have for wetlands) – what makes it a prairie vs. simply a grassland? Minnesota has a Guide/Key to Native Plant Communities; other states probably have something similar.
- Defining the phases of a reconstruction – when does establishment end and maintenance begin? Are there other phases?
- General questionnaire/survey for managers to fill out to describe the reconstruction process (how, when, why) through the whole project. This is a way to capture all the practices and knowledge that is already in the heads of our experienced managers. It would be beneficial for this to be a working document so that people can add their experiences over time. (Becky Esser has a starting point summarizing Larry Hanson's thought process).
- Identify which of our uncertainties may already have an answer in the literature. It may require hiring a contractor to help with this. Identifying specific research projects – e.g., economic analysis of reconstructions.
- Standardized format for what information we should record about our reconstructions. Consistently collected information would facilitate better and quicker learning. The may already be some products available that could help with this effort such as existing station forms, Refuge Lands Geographic Information Systems (RLGIS), R1 Refuge Habitat Management Database, etc.
- An AM project testing the effectiveness of reconstruction methods. This includes decisions about seed mix, establishment methods, post seeding management actions for establishing diverse reconstructions most quickly and cost effectively.
- Study to determine if treatment of Canada thistle positively influences success of a reconstruction.

- Continue down some road – don't let the workshop be the end of the discussions. Hopefully a core group is identified to keep things moving among a larger group of interested people.
- Use the steps that we identified in the workshop (e.g., site selection, seed mix…) as an outline that describes the process of prairie reconstruction, including ecological considerations that are tied up in deciding among management options at each step. (Influence diagram).
- Study plots for management options – like ag trial plots/field trials. Is the fate of a reconstruction predetermined or do our management practices actually make a difference? Control for seed mix and other characteristics.
- Explore developing a rapid assessment to look at abiotic and biotic factors at beginning of restoration and periodically after (10 yr intervals?).
- Develop a list of current research and projects that are ongoing or near completion that could help answer some of our questions (e.g., spike study, thistle study, NDSU economic analysis, etc.).
- Assembling records about the reconstruction steps (site selection, site analysis, seed mix, management, etc.) and follow up with some assessment of how the sites look today. Cost of management/restoration, and documentation of what we've done. R6 working with NDSU on something like this.
- Biologists doing the planning for reconstructions have a vision but struggle to get managers to go along (especially post-seeding management weed control). There are opportunities for education and communication between biologists and managers. It would be helpful to have more science behind the recommendations biologists make. It would also be helpful to incorporate operations folks into discussions throughout process.
- **Determine objectives**

Site Analysis

- Develop standardized protocol for site analysis/pre-planning of a reconstruction to help determine best seed mix and site prep methods (soils, seed bank, etc.).
- What are the effects of soil chemistry/nutrient loading on the reconstruction success and how we should use that information to mitigate or improve success?
- Study to determine which soil characteristics most influence success of reconstruction – soil carbon deficit, soil biota, aeration, etc.

Seed Mix

- Species list identifying all functional aspects of a plant – bloom time, pollinator value, etc.
- Research critical species for reconstruction like hemi-parasites and how to propagate them.
- Minimum sample size needed to accurately identify species list, seed purity and viability of a bag of native harvest seed (Research) – refine the question and decide what needs to happen.

- Develop a spreadsheet or database that would include functional group, seeds/oz. or lb., c-value, seasonality, aggressiveness, etc. for each species and could output forb:grass ratios, aggressive:conservative etc. for designing a seed mix. (Contract out?).

Site Preparation

- No Action Items/Products

Post-Planting Management

- Study to determine Best Management Practices during the post planting phase
- Develop a list of early detection rapid response species for which some spot spraying will be needed, and for those that have other management options. Possibly develop a regional integrated weed task force or plan.

What's Next

1. The workshop planning team will summarize the workshop information. Jill Gannon will provide some ideas regarding a modeling approach(es) in writing.
2. Workshop information will be shared via the workshop summary and webinars for those with an interest, but who could not attend the workshop. This includes partners who weren't at the workshop – MN DNR, TNC, other federal agencies, universities, etc.
3. An Advisory Team will be convened to review and discuss the workshop summary and decide on next steps. There will also be opportunities for smaller committees, specific projects, advisory roles, etc. We have a set of expertise and a set of uncertainties/needs, although some outside experts will be needed….match those experts and needs to work on some focused questions/projects.
4. Develop a directory of expertise.
5. Create a SharePoint site or email list to help share information (generally and as follow-up from this workshop).
6. Connect with the Grassland Restoration Network – share summary from this meeting and discuss ways to collaborate with them….community of practice.
7. Connect with the seed producers and seed vendors to communicate our needs.

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APPENDIX A – SCOPING CALL RESPONSES

CALL PARTICIPANTS

Jessica Bolser, Biologist, Port Louisa NWR
Kim Bousquet, Biologist, Big Stone NWR
Andrew DiAllesandro, Private Lands (PL) Biologist, Illinois PLO
Laurie Fairchild, PL Biologist, Rydell NWR
Scott Glup, Project Leader, Litchfield WMD
Mick Hanan, Biologist, Great Rivers & Clarence Cannon NWR
Steve Kahl, Refuge Manage, Shiawasee NWR
Diane Larson, Researcher, USGS-NPWRC
Jim Lutes, Biologist, Leopold WMD
Beth Oms, Acting Project Leader, Morris WMD (ALDP)
Laurie Richardson, Biologist, Lostwood NWR
Tom Skilling, Biologist, Union Slough NWR/Iowa WMD
Caitlin Smith, PL Biologist, St. Croix WMD
Karen Viste-Sparkman, Biologist, Neal Smith NWR

EMAIL INPUT

Marty Baker, Windom WMD
JB Bright, Morris WMD
Laurie Fairchild, Rydell NWR
Bill Johnson, Iowa DNR
Krista Reiser, Audubon NWR
Stephen Winter, Upper Miss NW&FR, Winona District

*compiled answers are based on multiple, similar answers

Q1: DEFINITION OF A SUCCESSFUL PRAIRIE RECONSTRUCTION (I.E. OBJECTIVES)

- It must be diverse- multiple species, functional groups, guilds, bloom in all seasons
- It must have Floristic Quality
- It must have structure; structural diversity and height/density across the reconstruction
- It must provide bird habitat (especially ducks), elicit wildlife response, pollinators
- It must contain Historic plant community present (realizing past land use is influential)
- Good success rate of planted species and acceptable interactions between planted species (i.e., dominance, etc.)
- Minimal management involved -relevant for both FWS field stations and private landowners
- The basic foundation of soil health is present (i.e., mineral, water, energy cycles functioning)

- The stand is dominated by native warm season grasses and high diversity of forbs
- The reconstruction is sustainable across soil types and water regimes, throughout changing weather conditions and management actions and still be able to withstand invasion of nonnative species and trees

*There are some specific goals/objectives already developed for some stations: Big Stone NWR & WMD, Morris WMD, Glacial Ridge NWR, Litchfield WMD

Q2: IF UNSUCCESSFUL, THOUGHTS ON CAUSE?

- Groundwater interactions
- Lack of diversity-missing species, guilds, functional groups
- Past Land use (plow layers, nutrients, etc.)-all impacts soil health
- Staff mistakes and oversights (lack of training, inadequate seedbed prep, inadequate planning, etc.)
- Unpredictable Factors (weather, equipment breakdown/failure, budgets, etc.)
- Not understanding site conditions (soils, seedbank, micro-fauna, nutrient loads, plant interactions)
- Inability to follow-up with management
- Might not be unsuccessful because it will still have more wildlife value than a crop field
- Poor seed viability due to storage conditions (heat) or pests
- Seed planted too deep (drill)
- Timing of seed dispersal (seeding)-example: forbs planted in spring (they are most successful planted in dormant season)
- Haven't' seen unsuccessful yet; it may take 8-10 years to see success and we must be patient
- We are measuring success against a moving target - different definitions, nothing concrete
- Not having the right information or understanding the processes and time it takes to reach "successful"

Q3: WHAT INFORMATION IS LACKING TO DO A BETTER JOB?

- Historic plant community information (in the form of remnant prairies or historical accounts/spp. lists, etc.)
- How to utilize abiotic factors to plan a reconstruction (weather, soils, etc.)
- What is the best seed mix, seeding rate (esp. grass vs. forb), seeding method
- How local is local ecotype seed?
- Importance of different micro-faunal spp and presence depending on soil type
- Site history information (may never be fully in our control)
- Information on planting into cover crops vs. bare soil/soybean stubble and establishment success?
- When is the best time to implement fire during initial establishment?
- Are our typical short-term management practices ok (i.e., routine fire interval) and are we doing them for the right reasons?

- What is the most effective weed management during establishment?
- What are the effects of long-term management (beyond the use of fire)?
- In general, what are the thresholds/triggers for management during establishment? From establishment to maintenance?
- Information for landowners -a checklist of what to look for and when
- What is the best timeline to measure success? Is it after three years? Seven years?
- How to establish species that are in the mix but don't show up in the planting
- What keystone species best outcompete weed invasion-are there species with allelopathic, competitive, or parasitic habits (i.e. gray-headed coneflower, stiff goldenrod) that can compete with non-planted weeds , when and how to plant them
- Soil tests and standard protocol
- Seedbank species and standard protocol
- Prairie definitions
- Pre-assessment for potential restoration success

Q4: What other limitations exist to initiate/expand prairie reconstruction at your station?

- MONEY
- Staff time to implement needed follow-up management (think short- and long-term)
- Availability of local seed (i.e. vendors, remnant harvest sites)
- Restrictions working with private landowners (knowledge/understanding, investment, accessibility to equipment)
- Accessibility to harvest equipment (combine) for large-scale harvests
- Limitations of seed drills, other equipment
- Staff/volunteer time to harvest enough seed; inadequate training on seed collection
- Inadequate training in plant identification for monitoring success

Q5: Top 3-5 components of prairie to monitor?

- Soil chemistry, other abiotic factors
- Species diversity, structure (VOR), composition, (question on definition for all three; should be easily comprehended), %cover
- Composition of dominant warm season grasses, exotic grasses and other exotic species
- FQI of reconstructed prairie-of what value relative to other reconstructions or to remnant prairies
- Species interactions or specific seed mixes to maximize wildlife response while minimizing weeds
- What is the minimum number of species (or what species are) needed to elicit a wildlife response (cost optimization)
- Comparisons of seeding methods, timing, etc. (think Thistle Study)
- Effects of management on species
- Seedbank- native and invasive seed presence and viability
- Insects (dung beetles, native earthworms, ants, pollinators?)

- Ground cover (%bare ground)
- Changes in soil structure (plow layer, roots, water cycle, etc.)
- Size of plantings and wildlife response
- Comparison of species planted to species established
- Ratio of native: nonnative species
- Where we spend our money; where we can free-up resources and where we need to spend

*What we choose to monitor must have predictive power across different areas, conditions, etc.

*Resilience: 1) ability for the prairie to resist invasive species invasion, and 2) ability to recover from a 5-10 year recurring disturbance event

APPENDIX B – DEFINITIONS AND ACRONYMS

Conservatism –fidelity to a high quality natural community

Functional group – C3/C4 species, species with various root strategies/depth, annual/perennial, legumes, etc. Strategies for survival.

Hemi-parasite – partially parasitic on roots of other plants

Reconstructed Prairie - one that has no bears no resemblance to a natural, native community before reconstruction efforts; it is not a remnant, native prairie; it usually has a cropping history and either start as black dirt or a degraded, planted grassland that was cropped at some time in the past.

Resilience – prairie community diversity such that the community can adapt to different environmental conditions (e.g., weather); a self-replicating system

Trophic levels – plants and animals, parasites and pollinators, predators

AM = adaptive management

BCA = bird conservation areas

BIDEH = Biological Integrity, Diversity and Environmental Health; USFWS policy

DBR = Division of Biological Resources

EDRR = early detection and rapid response

DM = decision making

GMT = Grassland Monitoring Team

I&M = Inventory & Monitoring

NP = native prairie

NPAM = Native Prairie Adaptive Management

NWR = National Wildlife Refuge

PLO = Private Lands Office

PLS = Pure live seed

SDM = structured decision making

SGCN = Species of Greatest Conservation Need

T&E = Threatened and Endangered species

TNC = The Nature Conservancy

WMD = Wetland Management District

USFWS = U.S. Fish and Wildlife Service

USGS = U.S. Geological Society

Appendix C – Miscellaneous

RESOURCES

- Seed calculator on NRCS website
- Shirley & Shirley book
- Seed catalogs
- Daryl Smith book (2010)

PARKING LOT/OTHER DISCUSSIONS

Landscape scale questions – LCCs are looking for landscape scale questions that influence prairie reconstruction. Includes climate change but also regional land use context, regional variation in management practices, etc. A lot of our original parking lot items fit here:

- How should we account for climate change? How do some of the discussions and uncertainties from this week relate to climate change? Planning our reconstructions for future climate scenarios – should our objectives be to recreate the prairie of the past or some different prairie of the future?
- Land use history influence on site prescription (farming history, nutrient loading)
- Does the size of a reconstruction unit matter? Edge effect, diversity, management implications.
- Landscape context. Position in watershed (e.g., higher in watershed is good), connectivity, corridors, priority areas, BCAs. Current land use surrounding a reconstruction site – biological and perception
- How reconstructions at a single site influence species that operate at larger spatial scales
- Bringing in multiple sources of information during conservation design step

OTHER

- "Linked decisions" - Relationship between establishment phase and maintenance phase – understanding how to affect the trajectory during the establishment phase to improve the maintenance phase. Can we get through establishment phase faster? Tools to get us there, site conditions that influence the length, etc. Triggers for intervention. Triggers to do certain site prep.